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Student-Created Test Sheets

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Assessment plays a necessary role in the high school mathematics classroom, and testing is a major part of assessment. Students often struggle with mathematics tests and examinations due to math and test anxiety, a lack of student learning, and insufficient and inefficient student preparation. Practice tests, teacher-created review sheets, and student-created test sheets are ways in which teachers can help increase student performance, while ridding these detrimental factors. Student-created test sheets appear to be the most efficient strategy, and this research study examines the effects of their use in a high school mathematics classroom.

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"The will to win is important, but the will to prepare is necessary," - Joseph Vincent Paterno, legendary college football coach at Pennsylvania State University

Introduction

Students in the United States of America are constantly found to score lower than their counterparts of other industrialized nations. This has been a consistent fact throughout the last three decades. According to the National Assessment of Educational Progress (NAEP), forty percent of fourth grade students and thirty-three percent of eighth grade students scored at or above the proficient level in mathematics (Mathematics and Reading Assessments, 2015). In addition, the percentage of high school seniors scoring at or above the proficient level in mathematics is only a mere twenty-six percent (2013 Mathematics and Reading, 2013). Of the thirty-four members of the Organization for Economic Cooperation and Economic Development (OECD), the United States ranked twenty-seventh in the field of mathematics (Desilver, 2015). These statistics were hard for me to read as a future mathematics teacher, but there is hope for mathematics education in the United States. National scores in mathematics have increased since their initiation in 1990 (Desilver, 2015).

As a future mathematics instructor, I have to wonder why the United States is lagging in the learning of mathematics compared to other industrialized nations. Students seem to struggle with performing on assessments, especially examinations, such as the standardized tests the statistics above are measured on. I believe this lack of competence in test-taking skills is due to three key points: a) students become anxious before and/or during taking a test; b) students did not properly prepare themselves and/or the teacher did not properly prepare the students; c) the students have not learned the material for whatever reason.

In the classroom, teachers use assessments to measure their students' knowledge of the course content. The four purposes of assessment, according to Dr. Daniel Brahier (2013), are: 1) monitor student progress, so as to promote growth; 2) evaluate programs, so modifications can

be made; 3) evaluate student achievement, in order to recognize accomplishment; and 4) make instructional decisions, so as to improve instruction (Brahier, 2013). Classroom testing is unlikely to disappear from the mathematics classroom, in the near future, at the high school and college levels (Thompson, Beckmann, & Senk, 1997).

Students may become anxious of these tests because of a phenomenon called math anxiety; this is where students develop nervous and/or anxious feelings when doing or preparing to do mathematics. Some students may become so anxious that they become too scared to attempt a problem, even when it is acceptable to get the problem wrong (Cook, 2015). Math anxiety causes a problem for students as it is likely to lead to decreased cognitive functioning, and math anxiety is, generally, associated with poor math performance (Bellock, 2014). Teachers, especially math teachers, need to acknowledge the fact that some students will possess some degree of math anxiety, which may cause them to perform below their capabilities (Cook, 2015). Teachers need to utilize strategies to help reduce math anxiety in their students, which is where student-created test sheets come in to play.

A key component to performing well on any test or examinations is proper preparation. This process of preparing for a test is called studying. It has been proven that study attitudes, habits, and behaviors are related to academic performance (Gurung & McCann, n.d.). In fact, when it comes to mathematics, students who are performing poorly fall into three main categories: 1) they do not have good study habits and/or do not understand how to study for a math class; 2) they study for hours each day but do not perform well; 3) they are not spending enough time studying (Hirsch & Goodman, 1994). It is the teacher's responsibility to not only teach students mathematics, but to also teach students how to study for mathematics. Having

students create test sheets is one of the ways teachers can help students figure out what study skills are the most efficient for them, as will be discussed in the literature review.

The literature review focuses on three resources teachers can utilize and implement into their mathematics curriculum to help students prepare for tests and exams. These three resources are: 1) teacher-created review sheets; 2) practice tests; and 3) student-created test sheets. Each resource will be explained in depth, and current research on each will be shared. By the end of the literature review, it will be shown that, according to recent research, student-created test sheets is the best of these three resources in helping students perform well on tests and exams by reducing student anxiety, promoting student learning, and teaching students how to best prepare themselves for a test. The purpose of this research is to determine how effective student-created test sheets are in reducing anxiety, increasing learning, and improving student study skills.

Literature Review

Teacher-Created Review Sheets

Teacher-created review sheets, also known as study guides, are resources created by the teacher and given to students to guide students' study times. These sheets often contain a list of topics and/or problems that will or might be addressed on an upcoming test. The purpose of these sheets is to organize lecture content and textbook materials so as to increase student comprehension and memory of large amounts of information (Srivastava, 2009). These review sheets "train" students what material is important, and they suggest that students only focus on the material on the review sheets. The review sheet serves as a positive reinforcement for which content is important for students to know, and it serves as a negative reinforcement for which

content students do not necessarily need to know. Review sheets relate directly to the behavioristic approach to learning (Lombardi, 2014).

Students often want a study guide from a teacher that has all of the content that will be on a test. They can then see what content they understand and what content they will need to study in more depth. Students intend for this to decrease the amount of time they need to study, while increasing their performance. But are review sheets as beneficial as students believe? Sanjay Srivastava (2009), an associate professor in the Department of Psychology at the University of Oregon, argues that review sheets do not make a difference in student performance (Srivastava, 2009).

Srivastava (2009) explains that he was troubled that often teaching strategies and practices are rarely tested or researched. He then asked himself the question, "Do review sheets help students prepare for tests?" and conducted his own research study. Srivastava says that he started his teaching career by refusing to give out review sheets, even when students protested. He explains that he thought review sheets were ineffective because of the two ways they can be created: 1) Listing the important topics, terms, concepts, etc. that students should copy; and 2) Making a document that actually contains study-able information on its own, for example, key formulas needed to be memorized (Srivastava, 2009). Both of these methods involve the lowest-order of learning, which involves factual knowledge, skill development, etc.; this directly relates to behaviorism (Lombardi, 2014). Srivastava thought the first method, which essentially was picking the headlines of lecture information and putting them into a list, was ineffective because students are already supposed to do this when they study, and giving students a review sheet would rob them of proper study time. In regards to the second method, Srivastava explains that this method does not apply to the courses he teaches, which mostly consist of psychology

courses. Srivastava decided he would give review sheets after the constant criticism of his students. Once he started handing out review sheets, he instantly received positive feedback from students who said the review sheets really helped their studies. Srivastava, though, questioned their effectiveness. (Srivastava, 2009)

Srivastava (2009) conducted his research during the week of the second midterm exam. The review sheet for this exam was posted online on BlackBoard one week prior to the exam. He utilized BlackBoard to track which of his students clicked on the review sheet and downloaded it; he linked this data to the students' test scores. Srivastava also tracked when the students downloaded the review sheet prior to the exam. He notes that students could have gained access to the review sheet by not downloading it, but he concludes that it is more reasonable to assume that students who did not download the review sheet did not use it at all (Srivastava, 2009).

This study included 327 students, 225 of which downloaded the review sheet at some point. Of those 225 students, 173 of them waited until the weekend before the exam to download it, while seventeen downloaded the review sheet on Thursday or Friday, and thirty-five downloaded it earlier in the week. In general, students who downloaded the review sheet did not perform any better than their counterparts. Srivastava (2009) explains that this was not highly controlled as he could not determine whether or not students who downloaded the review sheet actually used the sheet to study. He also explains that this study was not a true experiment; it was a simple study he utilized in his own classroom to determine if his review sheets helped his students perform better on a midterm exam (Srivastava, 2009)

In conclusion, Srivastava (2009) concludes that the data in this study is strongly suggestive; review sheets do not affect student performance on tests. He predicts that students

crave for review sheets because it offers them an "illusory feeling of control and mastery." He relates this to handing out lecture slides before a lecture; by not doing this, students have to take notes in their own words, which, Srivastava concludes, requires students to be more intellectually engaged with the material (Srivastava, 2009).

This research study suggests that review sheets do not increase student performance, which, consequently, limits student learning of the material. The positive of review sheets is that they help reduce students' anxieties prior to a test, even if this is "illusory," as Srivastava suggests (Srivastava, 2009).

In summary, review sheets appear to be ineffective for increasing student performance and student learning, but they do decrease student anxiety.

Practice Tests

Practice tests are a common preparation strategy for standardized tests. In fact, students and parents spend hundreds of thousands of dollars on test prep courses and practice tests to learn the secrets of a specific test. These courses and practice tests work well in helping students improve their scores on these tests (Dealing with Test Anxiety, 2012), but do practice tests have the same effect in the mathematics classroom?

Linda Bol and Douglas Hacker (2001) performed a research study to compare the utilization of practice tests and a traditional review on student performance and calibration, which is a student's accuracy in predicting his or her performance. I will use this study to discuss the effects a traditional review and practice tests have on students' performance (Bol & Hacker, 2001)

This study, by Bol and Hacker (2001), consisted of fifty-nine graduate students in one of two sessions of a required "Research Methods of Education" class. There was no significant difference between any of the students' grade point averages. The students' performances were measured on a midterm and final exam consisting of twenty-five multiple-choice questions on each exam and five and six short answer/essay questions on the midterm and final, respectively. The practice tests utilized were the same format as the two exams. One section, the treatment section, received a practice test and was given one hour to complete it; once they had finished, they were given forty-five minutes to review the practice test items with the instructor. The other section, the comparison section, had a more traditional type of review; this consisted of an hour and forty-five minutes of instructor-led lecture and interspersed student questions (Bok & Hacker, 2001).

We see that, for the group given the practice test, the instructor simply serves as a mentor. The teacher gives the practice test and creates an environment that simulates the testing environment. In essence, the teacher provides students proper resources and limits interferences, which directly relates to the humanistic view of learning.

Before the research was conducted, Bol and Hacker hypothesized that practice tests would be beneficial since students would be more familiar with the test items, have improved test-taking skills, have increased confidence in taking the test, and have higher levels of testing sophistication (Bol & Hacker, 2001). Bol and Hacker's hypothesis suggests that they support the humanistic view of learning because they believe the students given the practice test will perform better; they believe this because the students engage in higher-order learning through this practice and expertise on the practice test, a simulation of the actual test (Lombardi, 2014).

The results of this study contradicted the original hypothesis; the students who took the practice tests scored lower than the students who had a more traditional type of review. Bol and Hacker (2001) note that the practice tests were not formally scored and were only administered twice throughout the year. Scoring the practice tests and administering multiple practice tests could potentially enhance performance. From this research study, though, a traditional review is more beneficial for enhancing performance than administering practice tests (Bol & Hacker, 2001).

This conclusion begs the question, "Why do practice tests and test prep courses have such a positive impact on increasing student performance on tests like the ACT/SAT?" According to an article published by Cardinal Education, a non-profit organization whose mission is to help students become successful individuals through a variety of services, practice tests enhance performance because they help students become accustomed to the environment they will be in when they take the actual test. They claim that simply going over notes and using other methods to study for a test are not enough because it is not relatable to the high-stress situation students will be in when they take the test. When it comes to test-prep courses, Cardinal Education writes that student performance is increased because students are taking practices tests or test item questions in essentially the same environment they will be in on testing day. They say it is hard to create a simulation exactly like that of an actual test, but experiencing some of what the environment will be like will help students get accustomed to the high-stakes environment (Dealing with Test Anxiety, 2012).

It appears that practice tests help increase performance when they are utilized over a long period of time, as in an ACT test prep course. In a high school classroom, this luxury of time is not available. Because of this, I believe it is accurate to assume the conclusions of the research

study to be true; practice tests do not help increase student performance in the classroom. Practice tests may help decrease student anxiety, but they do not help increase student performance and student learning.

Student-Created Test Sheets

I have coined the term "student-created test sheet" to define what other research calls "student-created cheat sheets," or, simply, "cheat sheets." Because the term "cheat sheets" tends to have a negative connotation attached to it, I use "student-created test sheet" instead of "cheat sheet." As I discuss the literature on this topic, I will use my term over the term "cheat sheet."

Examinations have traditionally been classified as either open-book or closed-book. Closed-book examinations are those where the students have no access to any resources they can utilize during the exam; open-book examinations are those where students do have access to resources, including text books, class notes, handouts, etc., during the exam. Open-book examinations are beneficial because they reduce anxiety in students, de-emphasize memorization, and reduce cheating, but they are not beneficial because students tend to spend less time preparing for the exam than they would for a closed-book exam, and students tend to spend too much time perusing their resources during the exam; closed-book examinations have the opposite benefits and non-benefits (Raadt, 2015). Teachers often struggle finding an examination strategy that balances the benefits and non-benefits of each of these exams, but this process is difficult.

Having each student prepare his or her own test sheet and allowing him/her to utilize this resource during the exam has the potential to offer many of the benefits of an open-book exam, while overcoming many of its failings. The exam where students are allowed to utilize a test

sheet they created during the exam is neither an open-book or closed-book exam; this type of exam is an example of a restricted exam (Raadt, 2015).

A student-created test sheet is a notecard or sheet of paper on which students write notes, formulas, and any other information allowed by the teacher that is used during an examination (Erbe, 2007). The teacher can specify the size of the test sheet, and these sheets should be handwritten. Teachers can and should develop their own rules to determine what the student-created test sheet looks like in their class, and this format might be changed for each test, if so desired. In general, student-created test sheets can look different from class to class and test to test, but they should be handwritten, unique, and not contain any information or figures that are copied and pasted (Raadt, 2015).

It is already known that student learning is greatly enhanced when students study for exams and tests (Erbe, 2007), but do student-created test sheets reduce student anxiety, increase student learning, and increase student performance? Bass (2013) believes so; he claims student-created test sheets allow students to consider important vocabulary terms, decide what formulas need to be included, predict the types and kinds of questions that will be on an exam, flip through and review notes to scan over the content, look for trouble spots, and write all important things down (Bass, 2013). Recent research on this topic also supports the use of student-created test sheets.

Raadt (2015) conducted a research study at the end of an introductory programming course at the University of Southern Queensland. Eighty-nine students were involved in this study. The students were given one practice examination that mirrored the final examination, but the final examination consisted of new questions. Students were informed that they would be allowed to use a student-created test sheet and that these sheets had to be: handwritten; A4,

which indicates the size of the paper is 8.3 inches by 11.7 inches; double-sided; and contain any information they found to be relevant. The students were required to submit their test sheets with their examination. After the examinations were collected, it was determined that seventeen students, about nineteen percent, did not utilize a test sheet (Raadt, 2015).

Students who created and used test-sheets performed better, on average, on the examination, and certain features of the test-sheets were related to superior performance. Ordering information on the cheat sheet to match the sequential order of course content resulted in higher performance. Students who included abstract representations on their test sheets were more successful than students who did not include these representations. Raadt (2015) also noted that students who included answers from the practice examination on their test sheets performed poorly compared to their counterparts. From these results, Raadt concludes that students should be advised to do the following when creating their test sheets: 1) conduct a thorough review of the content and order the content to match that of the course content; 2) record generalized, abstract representations of concepts, rather than specific examples; 3) avoid writing answers from homework or practice tests in hope that the questions will be repeated on the test (Raadt, 2015).

Brigitte Erbe (2007), retired associate provost and chair of the Department of Teaching and Learning at Roosevelt Learning in Chicago, writes that she found student-created test sheets as a great resource for reducing test anxiety. She utilized student-created test sheets in her own classroom. She found that creating test sheets helped students better structure their study time and deepen learning. Erbe suggests that that the sheets are no larger than an 8.5-by-11 inch sheet of paper, are not copied from other students, and do not contain photocopies of text from books or articles. She also found that some students who created a test sheet did not even utilize their

sheet because the preparation of the sheet served as ample learning and studying for those students. Finally, she suggests that teachers make the test sheets fun by giving awards for the sheet that is most unique or creative and the sheet that contains the most information (Erbe, 2007).

Researchers have found that using student-created test sheets in the classroom reduces test anxiety. Test sheets reduce anxiety because most of student's math anxiety is focused on the first level of Bloom's Taxonomy of learning (Erbe, 2007). Bloom's Taxonomy outlines the types of thinking involved in problem solving. There are six levels to Bloom's Taxonomy that are typically shown in a pyramid where the levels go from bottom to top. The bottom three levels of the taxonomy are considered lower-order thinking and the top three levels are considered higher-order thinking. From bottom to top, the six levels of the revised Taxonomy, completed by Lorin Anderson in the 1990's, are: 1) remembering; 2) understanding; 3) applying; 4) analyzing; 5) evaluating; and 6) creating. The first level of Bloom's Taxonomy, remembering, is the source of most students' math anxiety because it requires students to recall and remember previously learned information. For example, being asked to state a formula, such as the area formula of a circle, is an example of a question involving this level (Bloom's Revised Taxonomy, n.d.). Allowing students to use student-created test sheets during an exam allows them to refer to the sheet for the lowest-order thinking problems of a test and use this information to solve problems of higher-order thinking.

Test sheets also increase student learning. Raadt (2015) states that preparing test sheets proved to be sufficient for learning what was on his test(s); students tailored the information to their own needs and wrote down the information they still needed to learn, allowing students to fill the holes in their own knowledge of the content (Raadt, 2015). Erbe (2007) shared this result

in her own personal experience, as she writes that, for students, preparing test sheets served as enough preparation and learning of the content on the test(s) (Erbe, 2007). It has also been found that students who are allowed to create test sheets may not even use their sheets at all because of the studying they did, while completing and preparing the test sheet (Grosz, 2008).

Test sheets also have another benefit because how students prepare their test sheets help students determine how they should study in the future. When students create a test sheet, they have to answer the following questions: "How do I organize the material?"; "Do I record data or the mechanisms used?"; and "Do I focus on what I know or what I do not know?" After preparing multiple test sheets and answering these questions multiple times, students learn how they should study in the future, whether it is for future math tests or for tests in other subjects (Grosz, 2008).

Many of the sources highlight the importance of the format of the test used where students are allowed test sheets. Tests need to require some sort of application, inference, analysis, or other questions involving higher-order thinking so that students cannot simply copy information from their test sheets directly to the test (Erbe, 2007). Tests need to have enough volume so that students cannot write all the test content onto their test sheets. It is also suggested that tests where test sheets are allowed should be given early in the course and should cover more material than other exams will cover (Grosz, 2008).

In conclusion, student-created test sheets reduce student anxiety and increase student learning, while increasing student performance.

Summary and Critiques

Throughout this review, we can see that assessment is necessary in the high school mathematics classroom, and testing appears to play a significant role of classroom assessment, especially in mathematics (Thompson, Beckmann, & Senk, 1997). Students often struggle in performing well on classroom tests because of math and test anxiety (Cook, 2015), because of a lack of learning in the classroom, and because of a lack of preparation by the teacher and, more importantly, the students (Gurung & McCann, n.d.). Teachers know testing is an important part in the classroom and can help aide student learning, so teachers often try to find ways in which they can increase student performance by ridding these three causes of student struggle. Some common methods that are used by teachers include teacher-created review sheets, practice tests, and student-created test sheets. Teacher-created review sheets help reduce student anxiety, but they do not appear to increase student performance or student learning (Srivastava, 2009). Practice tests have been found to increase student performance on standardized tests, such as ACT/SAT, when used in combination with test prep courses, but they have not been found to increase student performance or student learning in the classroom (Bol & Hacker, 2001). Student-created test sheets have been found to decrease student anxiety, increase student learning, maximize efficiency in the time students spend preparing and studying for a test, and increase student performance (Raadt, 2015).

I believe it is important to insert some critiques of the research. Many of the research studies utilized throughout the review are not specific to the mathematics classroom. Almost every mathematics teacher would agree that properly studying for a mathematics test or examination consists of many different strategies that are unique to mathematics only; one would not study for an English exam using the same techniques he or she uses when studying for a

mathematics exam. If the research was conducted in a mathematics classroom, the results may have been different. In addition, the research studies utilized often have small sample sizes, no comparison group, and are completed informally. For example, the research study conducted by Raadt only consisted of eighty-nine students. This may also cause some inaccuracies in the research studies.

In general, I believe the findings found throughout my review can be generalized to the high school classroom. This means that, of the three methods reviewed, student-created test sheets are the most beneficial tool for helping increase student performance on tests, while also decreasing student anxiety, increasing student learning, and increasing efficiency of study time. It is this test preparation technique that I will utilize in my own research study. I predict I will find similar results found by the research studies of Raadt and Erbe; allowing students to utilize student-created test sheets will increase student performance, decrease student math and test anxiety, increase student learning, and increase efficiency of student preparation and study time.

Methodology

The research study was conducted during my student teaching experience at Otsego High School in Tontogany, OH. The students involved in this research study were sixty-three high school students, mostly sophomores, taking the Geometry course I was student teaching. These students were taught by my cooperating mentor teacher (CMT) during the first one-and-a-half quarters of the school year, and I was an observer and assistant throughout this time. Under my CMT's instruction, the students showed various levels of performance and understanding of Geometry and mathematics. During my time teaching the students, I allowed two opportunities for students to create a test sheet for tests I created before I started collecting data.

To begin the research study, I first explained to my students what the topic of my research was, which involved defining student-created test sheets. Following this discussion, students took a pre-survey, which can be located in appendix A. This survey asked students questions about the following topics: current mathematical anxiety levels; what study skills they have utilized for mathematics; which of these study skills they found to be most and least beneficial for reducing mathematical anxiety, increasing student performance, and increasing student learning; the length of time spent studying for math tests; history with creating test-sheets; and their perceived usefulness of a test-sheet for reducing math anxiety, increasing student learning, and increasing student performance. Students who were absent on the day of the pre-survey did not complete one and were not involved in the data analysis of the surveys.

After the pre-survey was given, we began a unit entitled "Right Triangles and Trigonometry." This unit included the following topics: geometric mean, Pythagorean theorem, special right triangles, trigonometry, angles of elevation and depression, and law of sines and cosines. As we neared the end of this unit, I informed the students of the date of the test, and I distributed a 3-inch by 5-inch notecard. I informed the students that creating a test sheet was encouraged but not required and that they were allowed to use both sides of the notecard. Students then completed the test, which can be located in appendix B. All seventy students completed the test, and their scores were used for analyzing the relationship between test scores and whether the student created a test sheet.

Students then completed the post survey, which can be found in appendix C, the day following the testing day. The post survey included questions about the following topics: the math anxiety experienced for the test; the length of study time and the study skills utilized for this test; the completion of a test sheet for this test; the perceived effectiveness of creating a test

sheet for reducing math anxiety, increasing learning, and increasing performance; the number of times the test sheet was used during the test; the information put on the test sheet; whether a test sheet would be created for a test in the future; and general thoughts and feelings about the experience with test sheets. The students who were absent on the day of the post survey did not complete one and were not involved in the data analysis of the surveys.

Overall, sixty-three students completed a pre-survey, sixty students completed a post-survey, and twenty-nine students created and turned in a test sheet. The students who completed a test sheet were allowed to utilize the test sheet on the test. All of the sixty-three students were listed on an excel sheet with their test scores. It was indicated on the excel sheet whether the student completed a test sheet or not. This information was utilized to analyze the relationship between the student's test score and whether they created a test sheet or not. The surveys were created and completed using Google Forms, which was able to provide an analyzed report of the results from the surveys.

The twenty-nine test sheets were also utilized throughout the data analysis. The test sheets were separated into three groups, which depended on the creator's score on the test: 0-29 points, 30-39 points, and 40-50 points. One test sheet was chosen from each group as a representative of the average test sheet in terms of total information, organization, and neatness. The sheets were compared to try to find any differences.

Data and Analysis

The data gathered came from sixty-three high school students taking Geometry at Otsego High School. Of these sixty-three students, all of them took the test and were given the option to create a test sheet and utilize the sheet on the test, all students completed the pre-survey, and

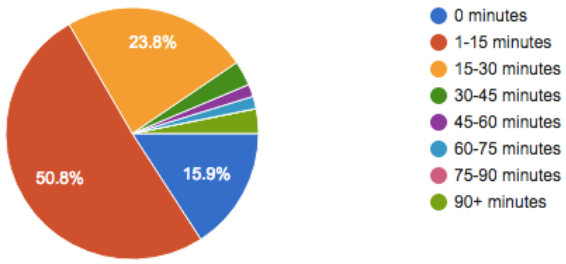
sixty of the students (95.2%) completed the post-survey. Also, twenty-nine students (46%) completed and turned in a test sheet, and twenty-three of these students (79%) completed a pre-survey and post-survey.

Test Scores

This test was scored out of fifty points. The average score the students received on this test was approximately thirty points, and the median score was twenty-nine points. Of the twenty-nine students that created and turned in a test sheet (46%), the average and median score was approximately thirty-one points. Of the thirty-four students who did not create and turn in a test sheet (54%), the average score and median score was approximately twenty-nine points.

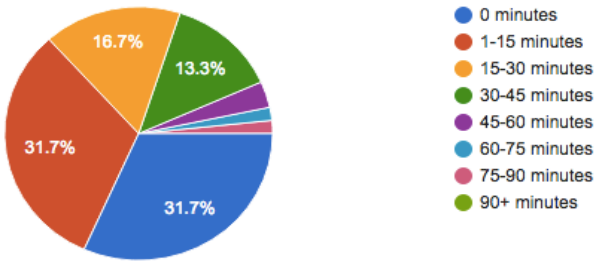
Study Habits

Students were asked the following question: How long do you spend studying for a typical mathematics test? The following chart depicts their responses. The key on the right indicates the number of minutes spent studying.



The responses indicate that forty-two students (66.7%) do not spend more than fifteen minutes studying for a math test, and only six students (9.5%) spend more than thirty minutes studying for a math test. This suggests that the average amount of study time a student spends on a typical math test is approximately nine to twenty-one minutes.

On the post-survey, students were asked the following follow-up question: How long did you spend studying/creating the test sheet for this test? The following chart indicates their responses.

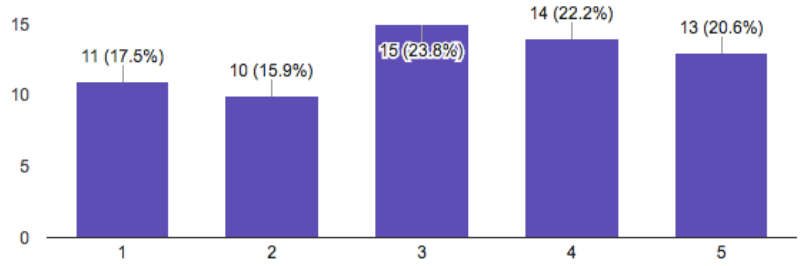


For this test, thirty-eight of the sixty students who completed a post-survey (63.3%) spent less than fifteen minutes studying, and twelve students (20%) spent more than thirty minutes studying for this test. This suggests that the average student spent ten to twenty-one minutes studying for this test.

The results indicate that the average student spent more time studying for this math test than he/she claimed to spend on the average mathematics test. When broken down further, the students who completed a test sheet studied longer than those who did not create a test sheet. The students who created a test sheet and completed a post-survey studied, on average, for sixteen to twenty-three minutes. The students who completed a post-survey but did not create a test sheet studied for six to fifteen minutes.

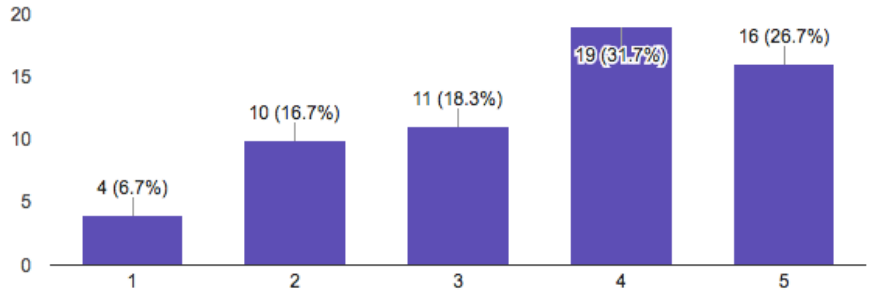
Reducing Mathematical Anxiety

The students were given the following definition for mathematical anxiety: Mathematical anxiety is an intense, emotional feeling that people have about their inability to understand and do mathematics. Students were asked how often they experience math anxiety, with one being never and five being always. The following chart depicts the responses to this question.



According to the results, fifty-two students (82.5%) experience some degree of mathematical anxiety. Twenty-seven students (42.9%) claimed to frequently experience mathematical anxiety (4 or 5 rating), while only eleven students (17.5%) claimed to never experience mathematical anxiety. The pre-survey results also indicated that approximately forty-six students (73%) believed that creating a test sheet would help reduce their math anxiety.

After the test was administered, students were asked about their levels of mathematical anxiety experienced on this test. The chart below indicates their responses (1- none, 5- intense).



According to the results, only four students (6.7%) did not experience any level of math anxiety for this test, while thirty-five students (58.3%) experienced intense levels of math anxiety (level 4 or 5).

There was an inconsistency between these two questions that made it impossible to draw any significant conclusions on the effects of creating a test sheet with reducing anxiety levels. The question on the pre-survey asked the students about how frequently they experience math

anxiety, while the question on the post-survey asked the students about the intensity of their anxiety levels.

On the post-survey, the students who created a test sheet were asked if they believed that creating and utilizing a test sheet was beneficial for helping to reduce their anxiety levels. Sixteen of the twenty-three students who completed a test sheet and post-survey (69.6%) claimed that creating a test sheet helped reduce their anxiety levels, while six of these students (26.1%) claimed that creating a test sheet had no effect on their anxiety levels.

Increasing Student Learning

The students were initially asked whether creating a test sheet would increase student learning. Around ninety-percent of the students agreed that creating a test sheet would increase student learning. Students were asked to elaborate on their response to this question. Some responses from students who believed that creating a test sheet would increase student learning include the following:

- "... it forces me to learn, let alone write, what is going to be on the test."
- "... because if I write things down I remember them better."
- "... if I see an example it might help me more."

Some responses from students who did not believe that creating a test sheet would increase student learning are the following:

- "... people just use it (to) help out their grade."
- "... (test sheets) are only used on the test. I could just put anything from the textbook on there and I really (wouldn't) be learning."
- "... you can just look up answers."

On the post-survey, students who had created test sheets were asked whether creating a test sheet helped with their learning of the mathematics content covered by this test. Of the twenty-three students who created a test sheet and completed a post-survey, nineteen (82.6%) claimed that creating a test sheet did help with their learning of the mathematics content.

Students were also asked how often they utilized their test sheet during the test. Eight of the twenty-three students who created a test sheet and post-survey (34.5%) claimed to have used their test sheet between only one and three times. Five of these twenty-three students (21.7%) claimed to have used their test sheet more than ten times.

Increasing Student Performance

On the pre-survey, students were asked whether they believed that creating a test sheet would increase their performance on a mathematics test. Sixty students (95.2%) believed that creating a test sheet would increase their performance on a math test. There were three students (4.8%) who did not believe that creating a test sheet would increase their grade. When asked to elaborate, two of the three students simply said "I do not know," as their reasoning, while the third student wrote, "... it doesn't increase the skills." Some of the responses from the students who believed creating a test sheet would improve performance are the following:

- "... I am forgetful and it gives me examples I can go off of."
- "... I wouldn't be as stressed out trying to remember how I do it."
- "... by knowing small formulas."
- "... I would be able to write things down and have an idea on how to do it so that way I don't get lost or not know what to do."
- "... (test sheets) can remind you how to do a certain problem."

On the post-survey, students who had completed a test sheet were asked to indicate whether they believed that creating the test sheet helped with their performance on the test. Of the twenty-three students who completed a test sheet and post-survey, eighteen of these students (78.3%) believed that creating a test sheet did improve their performance on the test.

The average score on this test was approximately thirty points. Of the twenty-nine students who created a test sheet (46%), the average was approximately thirty-one points, and of the remaining students (54%), the average was approximately twenty-nine points. On average, students who completed a test sheet performed two points better than their peers who did not create a test sheet; this makes a four-percentage-point differential.

Test Sheet Information

On the pre-survey, students were asked what types of information they put on their test sheets for previous math tests and other classes. Students were able to select as many as they wanted from the following choices: formulas and theorems, pictures or diagrams, example/homework problems, vocabulary and definitions, answers to questions I think might be on the test, and other. The most popular choice from the students was "formulas and theorems," where fifty-one students (81%) claimed to put this on previous test sheets. In addition, forty students (63.5%) claimed to have used "example/homework problems," and the same number of students also claimed to have used "vocabulary and definitions" on previous test sheets. Also, twenty-three students (36.5%) claimed to have put answers to questions they think might be on the test on one of their previous test sheets.

On the post-survey, the students who completed a test sheet were asked what types of information on their sheet were most effective and what types were least effective. Of the

twenty-three students who completed a test sheet and post-survey, two students (8.7%) claimed that diagrams were the most beneficial information on their sheet; thirteen students (56.5%) claimed that theorems were the most beneficial; and six students (26.1%) claimed examples were the most beneficial. Of the twenty-three students, five students (21.7%) claimed that answers to questions they thought would be on the test were least effective; six students (26.1%) claimed that diagrams were least effective; seven students (30.4%) claimed that vocabulary and definitions were least effective; four students (17.4%) claimed that formulas were least effective; and one student (4.3%) claimed that examples/homework problems were least effective.

The students were also asked what types of information they wish they would have put on their test sheet. One of the twenty-three students who completed a test sheet and a post-survey (4.3%) claimed that he/she wished he/she would have put more pictures/diagrams on his/her sheet; three students (13%) claimed that they wished they would have put more formulas on their test sheet; three students (13%) claimed that they wished they would have put more examples/homework problems on their test sheet; and sixteen students (69.6%) claimed they were satisfied with the information that was on their test sheet.

Each individual test sheet was placed into one of three groups, depending on the creator's score on the test: 0-29 points, 30-39 points, and 40-50 points. One test sheet was picked as a representative from that group; this sheet is what a typical sheet from that group looked like. The criteria for this selection included the total amount of information on the sheet, the organization or lack thereof, and the neatness of the sheet. The test sheet examples can be found in appendix D.

As the test sheets indicate, students that wrote more information on their test sheets tended to perform better than those that put minimal information on their sheets.

Student Perceptions and Overall Experience

On the pre-survey, fifty-nine students (93.7%) indicated that they have created a test sheet before. Of these fifty-nine students, twenty-eight of them (48%) indicated that they have created a test sheet for a mathematics test. On the test the students took during this research study, twenty-nine (46%) created and turned in a test sheet.

Students were asked whether they believe creating a test sheet would be beneficial for reducing mathematical anxiety, increasing student learning, and increasing student performance. Fifty-seven of the sixty-three students (90.5%) believed that creating a test sheet would be helpful for increasing student learning; sixty-one of the students (96.8% believed that creating a test sheet would increase student performance; and forty-six of the students (73%) believed that creating a test sheet would reduce mathematical anxiety.

After the test was administered, the students were asked the same questions on the post-survey. The following are the results of the students who created a test sheet and post-survey: nineteen students (82.6%) believed that creating a test sheet helped improve their performance on the test; twenty-one students (91.3%) believed that creating a test sheet helped improve their learning of the content; and seventeen students (73.9%) believed that creating a test sheet helped reduce their mathematical anxiety.

Students were also asked two questions regarding whether they would create a test sheet for a future test. The first question asked the following: Would you create a test sheet in the future if you were allowed to use it on a future test? Forty-nine of the sixty students who completed the post-survey (81.7%) claimed they would create a test sheet. The second question asked the following: Would you create a test sheet in the future even if you were not allowed to

use it on a future test? Seventeen out of sixty students (28.3%) claimed they would create a test sheet even if they were not allowed to utilize it on a test.

Finally, students were asked whether they enjoyed this experience with test sheets. Over half of the sixty students who completed a post-survey claimed to have enjoyed the experience with test sheets. One response from a student who enjoyed the experience was, "It's a great idea and helped me out greatly." One student offered the following suggestion for improving the overall experience: "We should use the test sheet for test, and possibly go over in class what would (be) good things to put on the sheet."

Conclusions and Implications

The data gathered in this research study offers interesting insights into the effects of creating a test sheet and increasing student performance, increasing student learning, and decreasing student anxiety.

Reducing Mathematical Anxiety

This research study does not provide enough information to draw any conclusions about students experiencing reduced mathematical anxiety levels when they create and utilize a test sheet. The reason this is the case is because of the different wording of the pre-survey and post-survey questions about anxiety levels. The pre-survey asks about the frequency of which students experience mathematical anxiety, whereas the post-survey asks about the intensity of the students' anxiety levels experienced on this test. There are two different questions being asked; therefore, it is not possible to draw any conclusions using the data gathered.

This does not mean that there is no possible relationship, positive or negative, between creating a test sheet and reduced mathematical anxiety levels. Erbe (2007) has found that student-created test sheets do have a positive effect on reducing students' anxiety (Erbe, 2007). In addition, the post-survey asked students if they believed that creating and utilizing a test sheet helped reduce, increase, or had no effect. Sixteen of the twenty-three students who completed a post-survey and test sheet (70%) claimed that creating a test sheet reduced their anxiety levels. This suggests that creating a test sheet does help reduce anxiety levels, which is similar to the findings of Erbe (2007).

Next time I would like to reconstruct the wording of the pre-survey and post-survey questions to more accurately assess the relationship between creating a test sheet and mathematical anxiety levels. With a refined research study, I could better assess the effects of creating a test sheet on reducing mathematic anxiety levels.

Increasing Student Learning and Performance

The results of this research study indicated that creating a test sheet did increase a student's learning of mathematics content and performance on a test, which is also the result found in previous research studies. The students who created a test sheet performed, on average, four-percentage points better than their counterparts; this suggests that students who completed test sheets increased their performance and learning compared to other students. Raadt (2015) also drew a similar conclusion.

It has been found that students who study more for a test or examination enhance their learning more than those students who do not study as much (Erbe, 2007). Of the students who completed a post-survey but did not create a test sheet, the average time spent studying for the

test was six to fifteen minutes, and the average amount of study time spent by those students who completed a post-survey and did turn in a test sheet was sixteen to twenty-three minutes. As the results indicate, the students who created a test sheet studied one to seventeen minutes more than their counterparts, which suggests that the students who created a test sheet increased their learning; this is similar to the findings of Erbe (2007).

The students' perceptions also suggested that learning was increased when students completed a test sheet. About eighty-three percent of students who created a test sheet and completed a post-survey claimed that it helped increase their learning of the mathematics content. In addition, eighteen of these students (78%) claimed to have used their test sheet less than ten times, which is similar to the findings of Erbe (2007). These responses suggest that student learning and, ultimately, performance were increased after the completion of a test sheet.

Next time I would like to try to gather more data on and find different means of assessing student learning and performance. This could be done through interviews with students, or by having students create a test sheet but not be allowed to utilize it on the test.

Test Sheet Information

It was found that there was a relationship between the information students put on their test sheets and their performance on the test. Students who used abstract images and diagrams (e.g. the students from the 30-39 points group) did perform better than some of the students who created a test sheet without using abstract images (e.g. the students from the 0-29 points group). The students that performed the best, though, were the students who included the most information (e.g. the students from the 40-50 points group). These findings somewhat support the findings of Raadt (2015), who found that the students who utilized abstract images performed

better than those students who did not, but the results of the research study to bring up an alternate conclusion (Raadt, 2015). This conclusion is: students who include the most information on their test sheets perform better than those who put less information on their sheets.

The next time I conduct a similar research study, I would like to provide more information to the students about test sheets. I could share with them the conclusion above, and then go through the mathematics content and create a test sheet as a class. Then I could have students create a test sheet in large groups, then small groups, and then, finally, individually. It would be interesting to see if the benefits of creating a test sheet are enhanced because of this experience.

Overall

This research study mostly reflected the same findings as previous research on student-created test sheets on the relationship between creating a test sheet and increasing learning and performance. No conclusions could be made about the relationship between creating a test sheet and reducing mathematical anxiety levels, but a refined research study would be able to provide more insight into this relationship.

Most of the students responded positively to the research study; students like creating and utilizing test sheets for mathematics tests. I plan on continuing to utilize test sheets in the classroom, and I will utilize the findings of this research study to help better the experience for the students to help increase their performance, increase their learning, and reduce their anxiety levels.

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Appendix

A. Pre-survey

The pre-survey was completed online via Google Forms. The following link will take you to the pre-survey: https://docs.google.com/forms/d/e/1FAIpQLSeZ3wxi7z6DW3rkM5APEBuZC_4tA8gLMXeaHOe25GKiSu4NSg/viewform

B. Test

Students took the following test, and the results of the scores on this test were utilized for data analysis. This was a test over two week's of content, which included the following geometry concepts: geometric mean, applications and the converse of the Pythagorean theorem, special right triangles (e.g. 45-45-90 and 30-60-90 triangles), the basic trigonometric functions, angles of elevation and depression, and the laws of Sines and Cosines. The test was worth fifty points, and the points of individual questions were indicated at the end of the question or beginning of the section.

Ch. 8 Test: Right Triangles and Trigonometry

Name: _____
Score: _____ / 50pts

Show all work on a separate sheet of paper!!!

Multiple Choice: (Write the letter of the correct response in the blank) (15pts; 3pts each)

Which of the following trios of side length measures will form a right triangle? ____

A. 7.5, 18, 19.5 C. 4, 9, 10
B. 9, 11, 14 D. 4.5, 5.5, 7.5

The measures of both legs of a right triangle are 4. What is the measure of the hypotenuse? ____

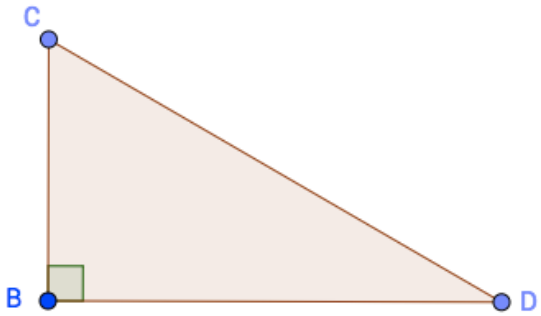
A. $4\sqrt{3}$ C. $2\sqrt{2}$
B. 8 D. $4\sqrt{2}$

What is the length of the legs of a 45-45-90 triangle with a hypotenuse of 20? ____

A. 10 C. 20

B. $10\sqrt{2}$ D. $20\sqrt{2}$

The triangle below is a 30-60-90 triangle, and the measure of side BC is equal to 13. Given this information, what is the measure of the hypotenuse, or side CD? _____



A. $13\sqrt{2}$ C. 26

B. $13\sqrt{3}$ D. $26\sqrt{3}$

Fill in the blank: The Pythagorean theorem states that the sum of the squares of the legs of a right triangle is equal to the length of the _____ squared. ____

A. hypotenuse C. smaller leg

B. larger leg D. perimeter

Short Answer: (Make sure to answer the questions fully) (35pts)

Find the geometric mean of the following pairs of numbers: (7pts)

a) 9 and 25

_____

b) 4 and 16

_____

c) 7 and 13 (round to one decimal spot)

_____

The following is a problem on angles of elevation and depression. Answer all parts for full credit. (12pts)

While surveying Overlook Cave, Mike measures the angle of elevation from his line of sight to the top of a rock formation as 22 degrees. The rock formation is 10ft away and he is measuring from a point 3ft above the floor of the cave.

a) Draw a diagram to help solve this problem. Label the diagram accurately. (5pts)

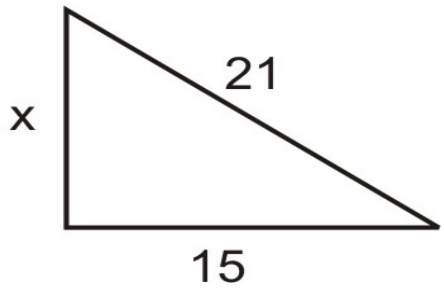
b) Which trigonometric function will you use to find the height of the rock formation? (2pts)

_____

c) What is the height of the rock formation, rounded to two decimals? (5pts)

_____

Find the missing variables by using trigonometry, the Law of Sines, or the Pythagorean theorem. (16pts)



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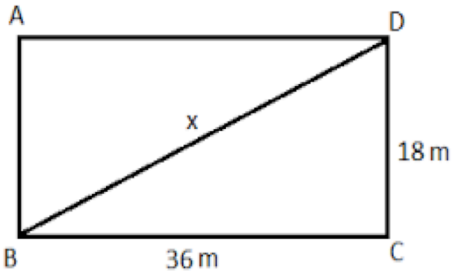

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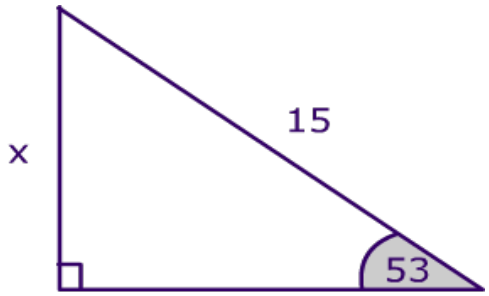

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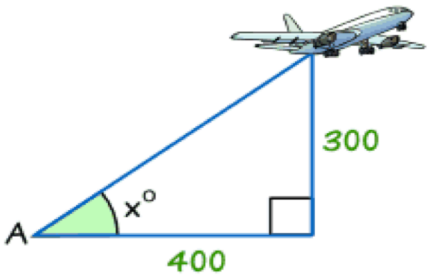

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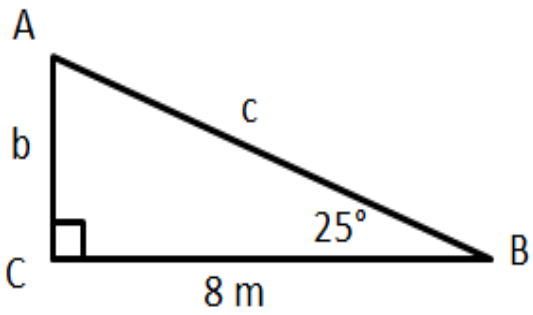

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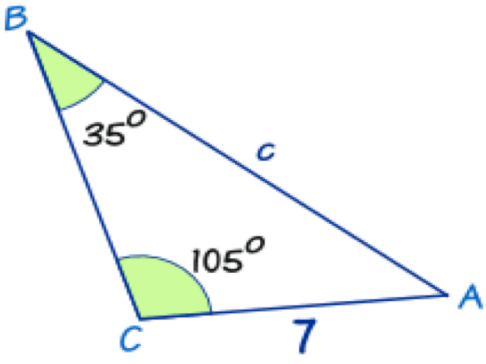


_____

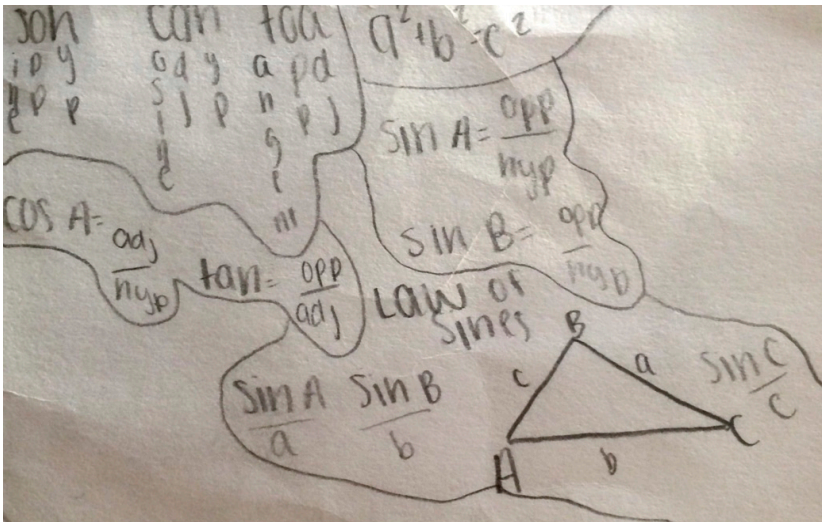
C. Post-survey

The post-survey was completed online via Google Forms. The following link will take you to the post-survey:

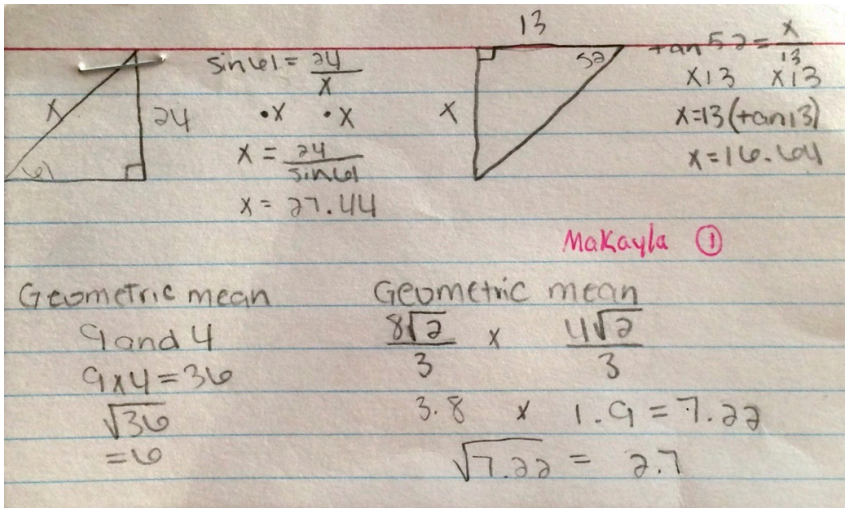
https://docs.google.com/forms/d/e/1FAIpQLSceCnn_zgDRzXLOlEvwydMyN4C9Fz_5ZpL4aGo9iks7HTaMuA/viewform

D. Student test sheet examples

The student test sheet below was chosen as the representative of the 0-29 points group.



The student test sheet below was chosen as the representative of the 30-39 points group.



The student test sheet below was chosen as the representative of the 40-50 points group.